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A Study of the possibilities of developing practical ceramic ware for charcoal cooking

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A STUDY OF THE POSSIBILITIES OF DEVELOPING PRACTICAL CERAMIC WARE FOR CHARCOAL COOKING

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INTRODUCTION

During the past ten years, the use of charcoal for cooking, both in braziers and in charcoal pits, has enjoyed increasing popularity, as more and more people have come to realize the benefits of charcoal cooking. According to James Beard, one of America's outstanding food authorities:

> "Everywhere I go, I find a revolution in American eating - the outdoors has come into the home. A new and exciting style of open-air eating is bringing fresh delights to diners on patios and in backyards - or in dining rooms and kitchenettes. And they're available in every season of the year."[1]

While more and more people are beginning to realize and enjoy the benefits and taste of charcoal cooking, both outdoors and indoors, over hibachis and similar equipment, there is a limited amount of ceramic cooking ware available for this type of cooking. I therefore decided to investigate the possibilities of developing such ceramic cooking ware, for a variety of reasons:

1) I believe that ceramic ware provides better tasting cooked food than metal ware, since there is no oxidation of metal, and since ceramic ware holds the temperature more evenly inside, in addition to keeping a more constant andlonger temperature.

1. James Beard, <u>Treasury of Outdoor Cooking</u>, Introduction

2) There has been a renaissance of interest in ceramic ware at the same time as an awakening of interest in charcoal cooking. Many people of so-called "modern taste" prefer the design and appearance of ceramic ware, and there is very little for these people to choose from in the field of charcoal cooking.

3) At the same time, I felt that such an investigation would give me much valuable experience and research information in the field of clay bodies, in which I have a strong interest, not only in the specialized area of charcoal cooking, but in clay bodies in general.

For this reason, I have at times branched out from the central problem of my research to consider also some aspects of over-the-flame and oven ceramic ware, but these have been related to the main focus of interest, the pottery for charcoal cooking.

I have approached this problem from several different angles, and tried a number of different approaches, some of which have been successful, and some of which have failed. However, the failures too have helped provide useful information on the subject, and I hope that on the whole my research and practical experiments have furnished a modest amount of help and insight into the problem of ceramic charcoal cooking ware.

The main purpose of this study was to try to develop, specifically, a ceramic charcoal burner, which could be used for indoor and outdoor charcoal cooking. Such a ceramic "hibachi" would provide the cooking advantages already outlined, as well as the possibility of much more variety and versatility in actual appearance and decoration.

In trying to develop such a ceramic charcoal burner, I have considered three fundamental parts:

1. the charcoal pot
2. the grill
3. the casserole

I have broken down the aspects of this study into a consideration: first, of the function served by each part; second, of the clays and, to some extent, the glazes, needed for such functions; and third, of the designs most suitable for these functions and into which the clays could be shaped. I of course tested the various theories worked out by practical experimentation and execution (photographs of the various results are included in this paper).

I shall now consider each aspect separately.

CHAPTER I

FUNCTION

1) <u>The Charcoal Pot</u>

The first and foremost part of the experimental combination is the charcoal pot. Unlike many of its Oriental cousins, such as the Hibachi, its function and construction will be solely for the cooking and heating of food over a charcoal flame. The hibachi as we know it today is used almost exclusively as a brazier, or at least this is the conception that we have for it in this country. In Japan, it is used mostly for heating the small rural and urban home, and incidentally for cooking from time to time. The hibachi known to the Japanese is a simple cast iron pot in which charcoal is burned. The more elaborate models are exported to the United States. Such more elaborate models are also of cast iron, in two or three basic shapes, with metal grates and usually small sliding ventilator doors. Some have metal basket inserts for the burning coals. The shapes are usually round, square or rectangular. Such pots function very well, and lack very little in effectiveness of design. What they do lack is variation in design, color and decoration. It is hoped that these problems of variation in design, color and decoration can be solved by using thrown and slab ceramic shapes for the charcoal pot.

The primary function of the charcoal pot thus is to provide a decorative and efficient container for the burning charcoal which will be used for the cooking and heating of food. The charcoal pot will also serve as a casserole warmer, and might be used as part of a matched set, coal pot and casserole. Used with a metal grill, it would serve as a brazier. If an effective clay body could be found, it could also serve as the heat supply for a ceramic fryer, although this last use was only briefly considered in the study under review.

The charcoal burner would be used for all the above purposes, while at the sametime providing the pleasant appearance and decorative aspect of ceramic ware, in contrast to the cast iron of the customary hibachi or outdoor grill.

Because of the characteristics of charcoal as a fuel, such a pot could be used both indoors and outdoors. Most of the pots could be placed directly on the table, without any fear of damaging the table top. They would also provide the advantage also provided by the cast iron burners, of being easily portable and movable from one place to the other.

As already mentioned however, the primary function would be to develop an attractive and at the same time efficient charcoal burner, giving the user the cooking advantages of ceramic ware as considered against metal.

2) <u>The Casserole</u>

The casserole as we know it is usually an earthenware pot with a cover, in which one cooks meats or vegetables. The cooking is done in an oven, which provides an even temperature on all sides of the pot. The cover on the pot provides a form of seal which keeps in the juices and flavor.

This baking process will not be of prime importance in this study. The casserole in this problem would be used as a receptacle for already cooked food, for the purpose of keeping it warm. In other words, the cooking itself would be done in the oven, and the charcoal pot in combination with the casserole used to keep the food warm, at the table, during the meal.

If suitable clay bodies could be developed, it might be possible to do some cooking in the casserole over the charcoal pot. Quite possibly, the uncovered casserole could be used as a fryer, or covered, as a small baker.

In this study, the casserole also played an important part in the testing of flame resistant clays, mainly because of its liquid holding shape.

It also provided more possibility for experimentation in shape and design than the charcoal pot, in which variations of shape were limited, to a certain extent. It also provided larger surfaces for glaze testing, which formed an incidental part of the study.

Its main purpose, however, would be to serve as an attractive food warmer, in connection with the charcoal pot.

3) <u>The Grill</u>

The grill would be placed in the usual manner on top of the charcoal container, or inserted near the top. With the grill in place, the charcoal burner would serve as a brazier.

An early attempt was made to make the grill itself out of ceramic material, but up to the point of writing this report, our efforts in this direction have failed. I still believe that such a concept is interesting, and should be possible to work out, given enough time.

Failing the use of a ceramic grill, the most dependable type of grill is a spot-welded, eight-gauge steel or iron circle or rectangle. Such grills can be purchased in most outdoor supply stores. Used or old stainless steel refrigerator shelves also work very well, if they can be cut down to fit the shape of the pot. Custom-made grills can also be obtained, but these are relatively expensive, although the cost is not prohibitive, by any means.

CHAPTER II

CLAYS AND GLAZES

One of the most important problems in this type of ceramic ware is in finding a clay composition which, when fired, will withstand heat and thermal shock. The lower section of the combination, or the charcoal pot, which will use charcoal as a fuel, will be subjected to great amounts of temperature changes. For example, charcoal, depending on the amount of air, or circulation of air, will burn anywhere from 700° to 2000° Fahrenheit. In other words, one small section of the charcoal pot may be heated to 1000° F while the rest of the pot may be at 700° F or below. This means that one section of the ware will be greatly expanded, while the rest will be contracted to its normal state. With the introduction of the two temperatures, the pot is now under greater stresses and strains, which, in almost all cases, will cause cracking.

The problem of elimination of cracking was approached from two directions:

1) The clay body should be dense enough to conduct the heat throughout the ware, so that the entire pot will expand evenly.

2) The clay body should be porous enough to enable the body to expand and contract in small sections, without disturbing the rest of the ware.

The first attempt was a dunt resistant body, suggested by American Ceramics. The body was taken from the results of a triaxial blend, which used a base of ball clay, china clay, nepheline syenite, pedalite, and the triaxial blend of flint, pyrophylite and zircon.

The first of this series of batches was straight; the second was with 10% buff grog; the third was with 1% by weight of fine sawdust, to make the body extremely porous. The ingredients were as follows:

	Batch I	Batch II	Batch III
Kentucky ball clay	2.5	2.5	2.5
xx saggar clay	2.5	2.5	2.5
nepheline syenite	1.0	1.0	1.0
pedalite	1.0	1.0	1.0
flint	1.25	1.25	1.25
pyrophylite	1.25	1.25	1.25
zircon	.5	.5	.5
buff grog		10%	
sawdust			1%

Bars were made of each sample, to record shrinkage, absorption and warpage.

Shrinkage results were as follows:

	Dry Box	c5	c9
Batch AC I	4.5%	11.4%	11.4%
II	3.6%	9.1%	9.1%
III	3.6%	10%	10%

The bars never warped.

Each bar was weighed dry and then boiled for two hours. A soaking period of two hours was added to the boiling to check absorption.

The results were as follows:

	c5	c9
Batch AC I	3.3%	1.8%
II	4.6%	1.6%
III	7.7%	5.6%

From these calculations, it was decided to run further tests for dunting and thermal shock. Pots would of course be needed. They were thrown into simple bowl shapes. This was also an opportunity to determine the throwing possibilities of the clay.

All three bodies were aged about one week. A new batch usually has a tremendous amount of air present in the body. Each body was thrown at least three times, with the following results:

ACI. One might consider this body impossible to throw. This is known as a thixotropic body. Only if very thickly thrown will it hold its shape. If pulled too rapidly, it will fracture in several places. A second try was made after it had aged for another week. Slip was used as a lubricant. The results were about the same.

AC II. This body was not quite so bad. It seems that the grog held it together somewhat, but it was still difficult to throw.

AC III. This too was an impossible body to throw. It was light with air, and dried very quickly, which made it fracture frequently during throwing. The addition of water only made the body more thixotropic.

At this point it was clear that these bodies were casting bodies. After a difficult time, six pots were made; three of each batch were fired at c5 and three at c9 for the dunting test, which went as follows:

As the first phase of the dunting test, all the pots were submerged in a large pan of boiling water for periods of 10 minutes. From the boiling water, they were quickly dunked into ice water.. All of the pots went through the test well over 10 cycles, and stood the shock with no signs of cracking.

The second phase was to place the pots into a hot kiln (400° to 750°) for 20 minutes, then into ice water. From the ice water, the pots were placed outside in a temperature of 6° F for 10 minutes, then directly back into the kiln for 20 minutes. This test showed the following results:

			400°	400°	400°	450°	500°	500°	550°	600°	650°	700°	750
AC	I	c5	OK	OK	OK	OK	OK*	OK*	OK*	OK*	OK*	OK*	OK*
		c9	OK	OK	OK	OK	OK	OK	OK	OK	OK	NG	NG+
	II	c5	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK*	OK*
		c9	OK	OK	OK	OK	OK	OK	OK	OK	OK	NG	NG✱
	III	c5	OK	OK	OK	OK	OK	OK	OK	OK*	OK*	OK*	OK*
		c9	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

* Showed large network of crazing, but no large cracks. The sound was still good.

NG. The sound was no good; and the pots still did not show any large cracks, however.

✱ Showed a network of small cracks.

Up to this point, none of the pots indicated large cracks. Batch II at c5 and batch III at c9 seemed to be the strongest so far.

The next stage of the tests was to boil water in each of the pots, directly over a bunsen burner.

AC Batch I - c5: Boiled water quickly and efficiently, and cracked across the bottom in the process. However, the crack was small.

II - c5: This pot would not boil water, and leaked, but did not crack.

III - c5: Boiled water slowly and held the water at a boil for quite a while after removing from flame (4 minutes). Showed slight cracking on bottom after a while.

AC Batch I - c9: Boiled water quickly, and showed cracking at the bottom, which caused leaking.

II - c9: Same as above.

III - c9: Same as above.

Even though all of the pots leaked at this point, there were still no cracks full enough to break the pots. Some pots still had a good ring to them (batch II at c5 and batch III at c9).

By now, all the pots were well seasoned to heat. The next step would be the final one. Each pot was filled to the top with charcoal briquets, which were lit while in the pot. Each pot was introduced to an artificial draft, because of non-burning qualities of the pot shapes. This was the shortest test to run, and showed the most results. All but one pot cracked. A later burning finally cracked the one remaining pot.

A close examination of the broken pots revealed that the bodies were full of air holes, which could have caused steam pockets. All in all, it seemed that batch II worked the best.

The next step was to mix carefully by hand a larger batch of No. II. Color oxides were added, to change the original chalky white II to a darker clay. This presented another problem in the selection of a suitable oxide which would not flux the body to the point of over-vitrification at c9. Melting temperatures of the various coloring oxides were compared, and manganese dioxide and black copper were selected.

Three 3000-gram batches were made, using 1500cc of water for each batch, which made it almost a slip mixture. This was an attempt to remove as much air as possible. The batches were given a sitting period of four days, in slip form, and one day in the drying bat, plus four more days after wedging. The results were as follows:

The basic composition of all three batches was:

Kentucky special ball clay	5 lbs.
cedar heights fire clay	5.5 lbs.
nepheline syenite	1.5 lbs.
pedalite	2 lbs.
flint	2.5 lbs.
pyrophylite	2.5 lbs.
zircon	1 lb.

Batch AC IV was 6.66 lbs. of the above batch.
Batch AC V was 6.66 lbs. of the batch plus 20% manganese dioxide (60g).
Batch AC VI was 6.66 lbs. of the basic batch plus 10% (30g) manganese dioxide and 10% (30g) black copper.

Test bars of the above three batches were made, to check shrinkage, absorption and warpage. The results are shown in the following tables:

Shrinkage

	Dry Box	c5	c9
AC IV	5%	7.3%	7.3%
AC V	5%	7.3%	8.4%
AC VI	5%	8.4%	7.3%

Absorption

	c5	c9
AC IV	5%	4.5%
AC V	1.6%	1.5%
AC VI	4.9%	4.8%

The bars never warped.

From the above tests, it was indicated that batches V at c5 and c9 were the densest, and batch VI at c5 and c9 had the most open body. The next step was a series of tests to see which would prove the most useful for the charcoal pot. From each batch two casserole-shaped pots were made. Three of each were fired at c5, and the other three were fired at c04. All the pots were filled with water and placed over a charcoal fire one at a time. All were too porous to boil water, but this was a good way to condition the pots to the charcoal heat. After the pots were thoroughly dried, they were filled with charcoal. The results were as follows:

	c04	c5
AC IV	Good	Failed
AC V	Failed	Failed
AC VI	Good	No large cracks, but bad sound

AC IV and AC VI at c04 seemed somewhat promising. Another small batch was made, and from it six larger casserole-shaped pots were made. Two were fired at c04, and two were fired at c9, with a slight wash of Albany slip inside while in the leather hard state. The two pots fired at c04 failed under the charcoal test. The two pots fired at c9 were intended for over-flame cooking ware. Both pots worked well while boiling water over a charcoal burner. The two remaining pots were fired at c2, at a later date, and failed under the charcoal test. So far, this body has proven itself for ovenware use, but not for a charcoal burning pot.

During the testing of the AC batches, several variations ona School for American Craftsmen stoneware body were made. This started when it was discovered that the SAC body with 20% grog proved very good in over-the-flame ware. This proved the open body would absorb more heat before failing. The next step was to find the point of failure.

A 38-lb. batch of SAC stoneware was made, and to it was added 20% grog (coarse). Test bars were not made.

This batch was used for the purpose of experimenting with the influence of heat on the various shapes, which will be discussed later. The composition was:

Batch S -	Kentucky special ball clay	12 lbs.
	xx saggar clay	12 lbs.
	dalton clay	6 lbs.
	North American fire clay	3 lbs.
	Bentonite - 2%	.46 lbs.
	Rediron oxide - 4%	.92 lbs.
	20% coarse grog	4.6 lbs.

From this batch, eight pots were made, two small casseroles and six charcoal pots. All were bisque fired. The two casseroles were glazed, and one was fired at c5 and the other at c9, and are still working. Two charcoal pots were fired at c04 and two at c5. All the charcoal pots failed, but were wired together, and later proved useful in checking the oxygen requirements for charcoal. One of the charcoal pots left in the bisque state was tested with a half-inch layer of coarse grog at the bottom, and worked extremely well for many burnings. This pot also finally failed. The failure could be due to three things: holes cut into the pot for ventilation, shape, or because it was only bisque fired. The last pot of this series, which was also in the bisque state, and without ventilation holes, was tested in the same manner and failed. These tests still led to the conclusion that the less vitreous the body the better it would work. This introduced the problem of having the pot too fragile to handle the stresses and strains which would always be present with the charcoal fire.

The next possibility would be to introduce a material which, even though fired high, would have a low coefficient of expansion. Alumina was used in the first batch, which was as follows:

Spodumine	83	lbs. or	27%
talc	100	lbs. or	32%
Ky. spec. clay	81.5	lbs. or	26%
alumina	49.3	lbs. or	15%

Shrinkage

	Dry Box	c04	c5	c9
AL I	5%	5%	16%	Bloated

Absorption

	c04	c5	c9
AL I	15.3%	5%	Bloated

The test bars sagged at c5.

The body threw very poorly. It seemed short, but was also thixotropic. Several small pots were made on the wheel, and one on a drape mold.

Two pots were fired at c04, and failed after two charcoal burnings. One pot was fired at c09, and also failed. Two were fired at c2, and worked for four firings before failing. The drape mold pot was fired at c2 and sagged beyond all usefulness. Needless to say, this body was quickly abandoned.

Later, tests were made which proved fairly successful for over-the-flame ware. Talc was replaced with Denver fire clay, and the percentage of alumina was doubled, which gave the following formula:

Spodumine	8.3 lbs.
Denver fire clay	5 lbs.
Ky. special	10.6 lbs.
alumina	7.4 lbs.

Because of the ever-present pressing time limit, only casseroles and small casserole-shaped pots were made. The casseroles are still working. If one is careful and uses the open gas flame carefully and slowly, these pots will work well for a long time. Even though this batch works reasonably well for over-the-flame ware, it did not stand up to the charcoal burning. All the pots which were used for the charcoal test cracked broadly, and clearly, into two pieces. No further tests were made with this body. However, it was not dropped completely. It threw well, and worked extremely well for casseroles.

From this point, it was decided to try another material with a high coefficient of expansion. Therefore, lithium was used in the next batch. It was decided that the SAC stoneware body would be used as a base, and to it lithospar was added, as follows:

Kentucky special clay	1.00
xx saggar	1.00
Dalton	.50
North American fire clay	.25
Bentonite	2%
red iron	2%

A 5.4-lb. batch of this was made, and to it was added the following:

flint	1.1
lithospar	3.5

(This group will be called Litho I, II, etc.)

Test bars were made, and gave the following

Shrinkage

	Dry Box	c04	c5	c9
Litho I	5%	7.5%	13%	12%

Absorption

	c04	c5	c9
Litho I	10.4%	5%	2%

This body was poor for throwing, even after two weeks of sitting. From this body, two fire pots and two casseroles were made.

One fire pot was fired at c04, and failed on the first charcoal burning. The other fire pot was constructed with large holes and stilts on which an insert would be placed with the burning coals. Even though this pot does not look good, it is still working. It was fired at c2 without any glaze. One casserole was fired at c7, and for some strange reason the body bloated and sagged beyond use. The pot was only glazed on the inside. After the lid was cracked off, it was used to boil water on a single burner flame, and cracked almost immediately.

It appeared that at lower temperatures this batch might make the grade.

One of the fire pots was fired at c04, and failed during the charcoal test. The other fire pot was fired at c5, and the results were the same.

It was thought that the lithium was causing the bloating, or it might be forming a eutectic with some other material in the batch. In the next batches, the lithium was reduced to 2.5 and 1.

Litho II-A	SAC	5.4	Litho II-B	SAC	5.4
	flint	1.1		flint	1.1
	lithospar	2.5		lithospar	1

The throwing quality of this body was only slightly improved over Litho I. Test bars gave the following results:

Shrinkage

	c04	c5	c9
Litho II-A	10%	15%	15%
Litho II-B	13%	10%	15%

Absorption

	c04	c5	c9
Litho II-A	19%	8%	4%
Litho II-B	9%	7%	3%

From these results, it seems the less lithospar the better the body. Next, test pots were made. From each batch two pan-shaped pots were made. Because of a slight tendency towards bloating, none was fired at c9. Of the four fired at c04, only one pot did not fail under the charcoal test, and that was Litho II-A, which disproved the first observation about the amount of lithium in the body. This pot lasted for several charcoal firings before failing, which was somewhat promising. All the pots fired at c5 failed when fired. At c5, the body conducted the heat very poorly. One could touch the pot veryclose to the burning coals.

From this point, it was decided to try another batch, using a color and grog. The lithium was brought back to 3.0, which gave the following batch:

SAC	5.4
flint	1.1
lithospar	3
coarse grog	20%
red iron oxide	6%
manganese dioxide	1%

Litho III

	c04	c5	c9
Shrinkage	7%	13%	17%
Absorption	11%	8%	4%

Again, the bars started to bloat at c9. Several sizes and shapes of casseroles were made, as well as larger casserole-shaped pots for testing. One large charcoal pot was made, and up to this point it has not failed. Possibly the reason for its not failing could be the fact that a layer of sand is used as an insulator inside the pot while burning the coals.

All the casseroles were fired between c5 and c6, and almost all the lids sagged. Testing the casseroles for over-the-flame ware was done over the single flame bunsen burner, and they all failed. By now, this body has proven unworthy for this problem.

It was suggested by one of the other students to try one of the flame-proof bodies with which he had had good results at his last college. At this point, I was ready to try anything. The batch was composed as follows:

5.0	Cedar Heights (should have been AP Green Plastic fire clay)
16.0	Kentucky ball clay
3.5	Keystone
3.5	sand
1.6	iron oxide

This batch was modified slightly to change the color, as follows:

CH 5.0 Cedar Heights
16.0 Kentucky Ball clay
3.5 Keystone feldspar
3.5 sand
1.5 manganese dioxide

No test bars were made, only charcoal pots and casseroles, and one tea pot, to test its throwing qualities, which were good. The casseroles are still working. However, the charcoal pots failed under the fire test. Further modifications were made on this body, to improve its refractory qualities. Alumina was used to replace the sand, and pedalite was used to replace the keystone, giving the following composition:

5.0 Cedar Heights
16.0 Kentucky ball
3.5 pedalite
3.5 alumina
1.5 manganese dioxide

29.5 lbs. batch

Several casseroles and test pots and bars were made after the clay had had sufficient time to age. The clay threw extremely well. It also dried quickly, which made it easy to remove from the wheel head, without distorting the shape of the pot.

The test bars revealed the following information:

		Dry Box	c04	c5	c9
PL	Shrinkage	8%	12%	14%	15%
	Absorption		18%	14%	4%

One large charcoal pot was made, which was constructed with a liner, and is still working. One large casserole was also made, and because of its good appearance was not sacrificed for the over-the-flame test. However, it has been proven for oven ware. Up to this point, this body seemed to work the best. At least, one might say that it comes closest to a pyroceramic than any of the other bodies.

The insert used for the above charcoal pot was a fire clay and magnesium body, which absorbs water as though it were a sponge at c9, and has not completely proven itself so far. Because of its difficult throwing qualities, it was abandoned, but not before several slabs were made. The slabs fired at c5 resembled bisque ware. At c9 it failed to hold together with the burning coals on it. In this case, it is believed that the failure is due to underfiring. Only a rough estimation can be made of its maturing temperature, and that would be upwards of c12. Strangely, the one plate which was fired and failed at c9 has only cracked in one place, and the crack has not enlarged itself, even after several charcoal firings.

Inasmuch as the AC batch somewhat proved itself, it was decided to modify it with colorant oxides and grog, and give it another chance in larger pots. Only a few changes were made in the batch formula:

Kentucky special ball clay	2.5	
Denver fire clay	2.5	
nepheline syenite	1	
pedalite	1	
alumina	1.25	
pyrophylite	1.25	
zircon	.5	
red grog		20%
iron oxide		5%

A 40-lb. batch was made up, which threw extremely well, much better than the previous AC bodies. The test bars revealed the following:

		c04	c5	c9
AC VII	Shrinkage	6%	13%	14%
	Absorption	18%	7%	4%

From these results, it was decided to fire one of the larger fire pots at c2 unglazed; after firing the pot was lined with about 2 inches of sand, and was used successfully as a charcoal burner.

One pot was fired at c5, and even though it also had a 2-inch layer of sand, failed. The failure might have been due to the thinness of the pot. The c2 pot was heavily thrown. The two remaining pots have not been fired at this point. They will be fired at c2 with glazes shortly.

Other bodies which are worth mentioning are a straight Denver fire clay, which works very well for lower shapes, such as casseroles or pots which could be used for over-the-flame ware. Test bars were not made. However, several test pots were made, and fired at c04, c5 and c9. These pots were tested for over-the-flame ware. The c04 pots were much too porous and would not boil water, but did not crack. The one pot fired at c5 was completely glazed and stilted in the kiln. This pot did boil water without cracking, but it was still porous, and even though it was glazed, water did seep through the body. The pot was tested several times, and always proved dependable, without cracking; also, the sound never changed.

The remaining pot was fired at c9, after being completely Albany slip glazed. This pot failed on the first try. It was thought to try this body for better possibilities between the c5 and c9 range. Another small batch was made, but the results will not be ready for the completion of this paper.

Another of the final body tests was straight Drakenfeld fire clay, with 20% red grog. The results of this test were almost the same as those for the straight Denver fire clay - c5 worked for water boiling, but was still porous, c9 failed. The one impressive thing about this clay was its throwing possibilities. The clay threw extremely well.

Test bars revealed the following information:

		c5	c9
DF	Shrinkage	10%	14%
	Absorption	9%	4%

The last test was straight Ohio fire clay, which threw very poorly. High shapes are almost impossible to achieve. Because of the rough grog-like material, the clay dried quickly, which made it too short for throwing. With the addition of slip for a lubricant, the body suddenly became thixotropic. Only two small deep casserole-shaped pots were made, and both failed for boiling water. The pot fired at c5 was reglazed and refired at c64 and did boil water over the charcoal heat. Because of the time limit, no further tests were made with this body.

To summarize briefly this section on clays, it appears that none of the bodies is what the author would consider completely successful. However, there are a few which will be carried further at a later date for this very same problem. The four bodies which will be used for the attempted completion of this problem are AC VII, PL, CH and S series.

GLAZES

In this section on glazes, only a few of the more successful batch formulas will be listed. Inasmuch as many of the charcoal pots were only slip decorated, the glazes were used mostly for the casseroles.

The formulas listed will be base formulas, which were gathered from advisors, Rhodes, Norton, Nelson, colleagues, and various periodicals in the field.

c5 - A good, opaque white which takes colors very well, and was mostly used for the insides of casseroles:

B18E

Cornwall stone	20
flint	25
Dolomite	20
kaolin	20
frit 3134	20
tin oxide	4
lithium carbonate	2

c9 - A good opaque base, which responds very well to colorants in low percentages:

B12

Bainbridge	20
kaolin	20
flint	30
Dolomite	20
frit 3134	20
tin oxide	10

c5 - c8 - A good base matte finish, which works well for the outsides of casseroles. Shows applications, and works well with oxides in low percentages:

SPA

Whiting	20
Cryolite	5
Barium carbonate	20
Zinc oxide	9
Bainbridge	84
Kaolin	17
Kentucky ball clay	16
Flint	20

c9 - A good, crystal developing glaze for many kinds of interesting decorative effects:

A39

Cornwall	20
Flint	33
Kaolin	20
Whiting	14
Magnesium carbonate	5
Zinc oxide	20
Nickel	2
Tungstic acid	1.5

c5 - A good semi-mat base which has an expanded firing range and responds to colorants, and does not show applications:

WM

Whiting	8.0
Potash feldspar	66.4
Kaolin	25.6

c5 - Clear white base, does not show applications, but does show when colorants are used:

PH

Pedalite	25
Dolomite	25
Flint	5
Kaolin	25
Frit W15	8

c5 - An interesting brown glaze which works well for outside use:

S

Spodumine	20
Flint	20
Dolomite	20
Barnard clay	20
Frit 3124	20

c5 - A good opaque semi-matte white base, which takes colored oxides well, also works well with slips:

B18MA

Cornwall	20
Frit P626	74
Dolomite	20
Whiting	7.2
Kaolin	44
Flint	2

As mentioned before, these are a few of the more successful formulas used during the course of my experiments.

CHAPTER III

DESIGN

Problems in design are almost as complicated as finding the proper clay body.

The section on design will be divided into two parts:

1) The design and the problems influencing the design of the charcoal pot.
2) The design of the extra equipment, which will include casserole, soup tureen, grill and wooden feet, or some method of placing the charcoal above the table.

I. Charcoal Pot

A. Materials

The charcoal pot will have many factors influencing its design. The first most influential is the material from which the pot will be fabricated. Generally, most materials which are closer to a pyroceramic are more difficult to throw on the potter's wheel. For this reason, many of the shapes are simple and quite basic inform, which later proved to work better than the more complicated shapes.

Whenever possible, the shapes were thrown; however, if the clay became too difficult to throw, the pots were slab constructed (Illustration 1). In most cases, the shapes were not over 8 inches high, which, even though the clay imposed a height limit, was not too difficult to achieve.

Illustration 1

The addition of refractory materials also tended to make throwing and shaping difficult. This problem was generally solved by using the high percentage grog clays for slab construction.

One possibility which was not explored was the use of the jiggering method for the more difficult throwing clays.

B. Fuel and Air Supply - Influence on Design

The most basic shape for this problem would be the old and dependable closed bowl shape, one in which the top or opening closes back in slightly. This would work well as a receptacle for the burning coals. However, because of its smaller opening, it would prove useless for the purpose of this type of problem. Would not a cylinder work just as well?

As a matter of fact, the first experimental shapes were almost straight cylinders, and when wired back together after cracking, they worked well for charcoal receptacles. These pots would also work well enough as a brazier, placing a small grill on the top. As long as there was enough air supply, the coals would burn. However, if a good-sized casserole or pan was placed over the coals, part of the air supply was cut off, and there was no burning.

Several methods were employed to maintain enough oxygen for the coals. One was to cut holes in the side of the pot between the top lip and the burning charcoal (Illustration 2). This worked, but gave the pot an unclay-like quality. Good or bad, however, these holes served two purposes: For some reason, the addition of the holes seemed to keep the body of the potcooler, and at the same time allowed the charcoal to burn hotter. The next step was to find some way to ventilate the pot without making it look cut to pieces.

Attempts were made to push the holes through while the clay was still ina throwing state (Illustration 3). This improved the looks of the pot, but did not improve the ventilation problem. The holes must be large, and close to the top edge of the pot. Holes cut through the center or below presented two problems: 1), the heat was too well ventilated to reach the top of the pot, where it was needed; 2), the charcoal dust would not remain inside the pot. The slightest draft would scatter dust about in seconds (the most successful attempt to remove the dust problem was to bring the top edges of the pot to a smaller circle). (Illustration 4).

The next step was to try in some way to keep the pot in shape without ventilation holes, by placing some type of spacers on the top lip of the pot. This provided the necessary ventilation when using a casserole or fryer. It was later discovered that the spacers could also be used as handles for the charcoal pot.

Illustration 2

Illustration 3

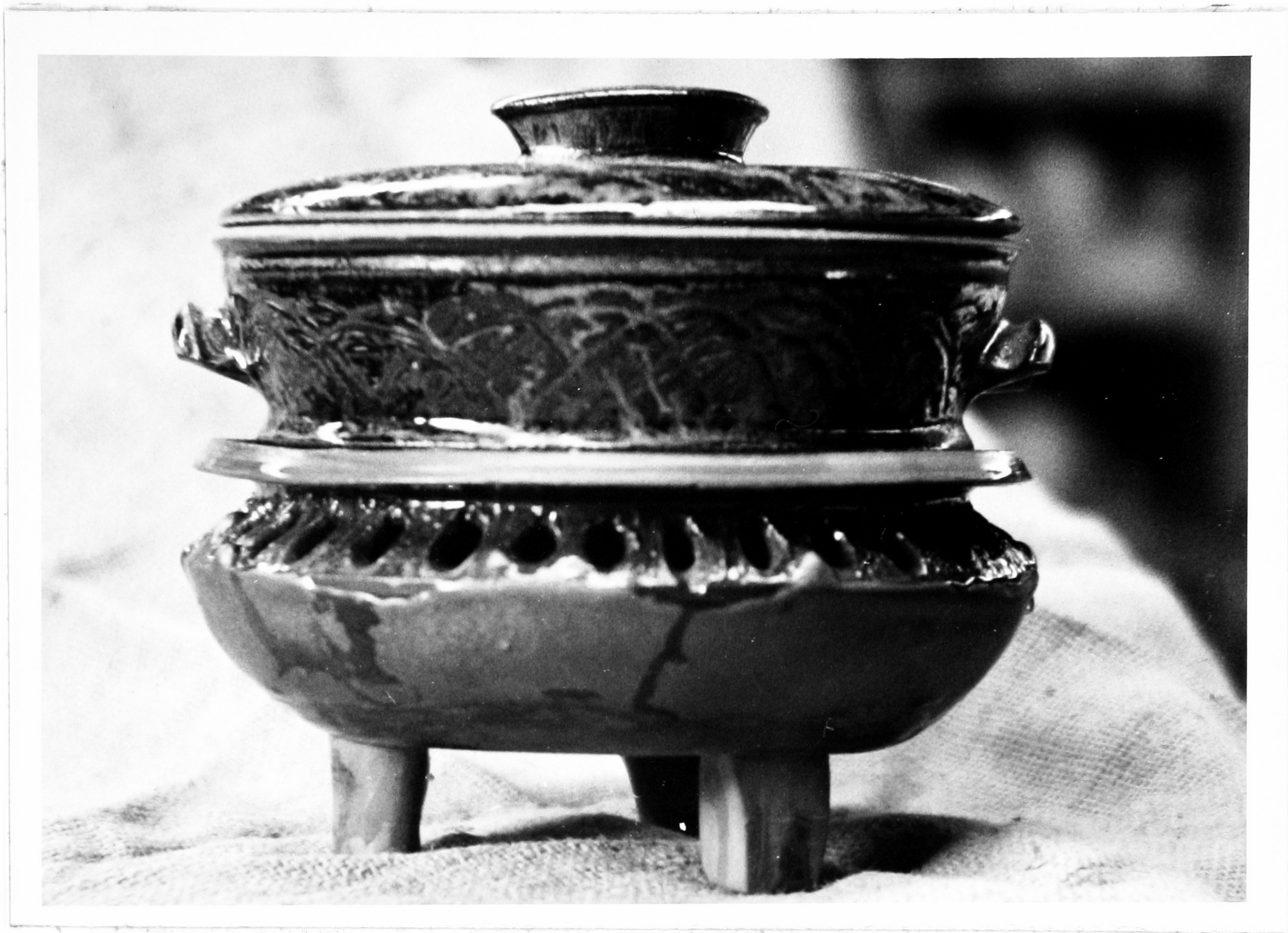


Illustration 4

Early attempts for maximum air circulation were made by throwing a bowl-shaped insert and perforating it with many holes. This would stand on stilts inside the charcoal pot and act as a coal basket. This system usually provided the most heat for a given number of briquettes. However, it always broke the insert. Several flat fire clay dish type inserts were also tried and were successful for fuel burning, but not for staying in one piece.

The last and most successful method so far, which allows the pot to be in any shape, is using a refractory liner, which could be sand, grog or crushed fire brick.

C. Elevating the Charcoal Pot

In most cases, the charcoal pot would be used on a table or counter top. This presented a problem of the heat's burning the table tops. Several methods could be employed to solve the problem. In Japan, small wooden legs are bolted to the cast iron pots. A somewhat unaesthetic method would be a small asbestos pad. The most promising method so far is elevating the pot enough to give it enough air circulation under it. This was first accomplished by using pulled legs on the base of the pot (Illustration 3). The next step was to use a thrown ring foot. This did not work too well. The trapped warm air under the pot would be a little too much for the average table top. Later attempts were made by cutting holes in the thrown foot. This worked well, but not as well as the pulled feet. The next attempts were made by using grog or sand as an insulation in a footless pot. For average service, this method would work, but if the pot were to be used for more than one hour, it would be too hot for table use. From this point, using the same idea of the grog or sand in a footless pot, it was decided to make a two-section pot, each thrown and fired separately, which later could be pieced together. The foot section would be a cut low cylinder (Illustration 6), which would fit the charcoal pot. At the risk of being gadgety, this worked rather well. From here, the problem of stilting was taken to its extremes by footing the charcoal pot 20 or so inches above the ground (Illustration 7). This was an attempt to find the possibility of using the combination off the table or on the floor. So far, it has not been tried, but it will work as long as the lower unit is heavy and stands soundly. This would also be fired in two sections. In this larger foot problem, the most consideration should be given to its size proportion, which at this stage is still questionable.

The last method tried was to use slabs joined together to fabricate the foot section. The slab method works well because of its size variability (Illustration 8).

From what has been done so far, it has been decided that there is no set solution for footing the charcoal pot. Whatever best fits the situation will do.

Illustration 6

Illustration 7

Illustration 8

D. Size

The size of the charcoal pot depends mainly on its use. Should it be used for braziers only, it can be anywhere from 8 to 12 inches in diameter. However, if it is to be used as a combination unit - brazier, casserole warmer, soup warmer, its size is limited to the size of the casserole or soup tureen.

Another limiting factor would be where it is to be used - indoors, outdoors, table or floor.

Whenever possible, the table models all have a somewhat low silhouette. The floor and outdoor models were made as large as the clay would allow. If a unit is to be used for the table, it should not be larger than a medium-sized platter, 8" to 12", otherwise it will be too large for the average table.

II. Extra Equipment

A. Casserole

Little can be done to improve the basic, familiar design of the casserole, and in this problem little indeed was done. However, a few problems did arise in fitting the casserole to the charcoal pot, the use of protruding handles, size, and shape relationships.

The first problem in this area was the size of the casserole. Casseroles range in size anywhere from the two-inch single serving up to the large 20-inch family size. As mentioned before, the casserole in this problem would be used primarily as a warmer. For this purpose larger sizes would be more desirable. However, the larger sized casserole would be somewhat difficult to handle while using it with the charcoal pot. For this reason, three to four,6" to 10" serving casseroles were made. Another important factor in determining size is the casserole depth. If it is to be used only for warming, the shallower the better. The deeper shapes would be impractical for this purpose. Three-inch deep casseroles, which proved the most dependable, were about 8" in diameter and 3" deep. The larger shapes sometimes developed cracking problems, whereas the smaller did not.

Shapes, as much as possible, were kept clean and simple (Illustration 9). Some casseroles were thrown directly after throwing the charcoal pot, with the intention of relating the shapes as much as possible.

Illustration 9

Handles were of particular importance in this problem. The heat from the charcoal pot can be quite intense. Fortunately, the heat only affects the lower section of the casserole. For this reason, the handles were placed higher and away from the charcoal pot. Some regular spout-type handles were used, and so far have proved to look and work well.

B. Grill

Whenever possible, the metal grills were placed below the top rim of the charcoal pot. In this way, one would only see the pot, with the grill somewhat hidden.

In the beginning, when ceramic grills were tried, the grill was shaped more like a platter, with holes, which was placed on top of the top. In most cases, the overhang of the grill was at least 1.5 inches, which allowed one to replace coals by using the overhang as a handle (Illustration 10). Unfortunately, the designated ceramic grills have not worked quite well enough so far.

Unless the metal grill were to be custom made for the pot, with handles, there would be a slight problem of removing the metal grill for fuel replacing. It was later decided that the problem was not serious enough for further consideration. A fork used in much the same way as a hot-plate remover in a wood stove would do well for the job.

No special emphasis was placed on the grills, except that the pots were thrown within a fairly close tolerance of the standard sizes of grills, which in this case were 8", 10" and 12 ". Larger grills were improvised with steel rods which ran through the pot (Illustration 11). This did work, but left much room for improvement. In the few remaining school days, the grills were made for the pots after the final firing. Thisprovided a much neater appearance for the pot, and seemed, for all practical purposes, to solve the grill situation.

Illustration 10

Illustration 11

CONCLUSION

In this chapter, which theoretically should be devoted to the solution of the problem posed, I shall present, in pictorial form, what I consider a provisional and tentative solution to the problem, given the time limits under which the study was made. I do believe that a full and completely successful solution can be found, with more time and research.

In the pictorial presentation, I shall present with each picture a short explanation of the clays, glaze and decoration used, how the article was executed, and why I think it is worthwhile or significant.

Before beginning the presentation, however, I would like to mention briefly a few points which I did not explore, and some possible improvements which might be made, for which there was no time during the course of this investigation.

One of the many possible improvements on the charcoal pot would be a metal insert in the lower section for the burning coals, something like a pie tin.

It was also thought to try using a large thrown lid over the grill, which could make it a baker of sorts.

One might also consider the possibility of cooking the food directly in the coals, as might be done with a potato, for instance.

Also, in regard to stilting the charcoal pot, one might consider using a wrought iron frame for stilting.

All the fuels used for this experiment were concentrated charcoal briquettes. It might be a good suggestion, for the longer life of the charcoal pot, to use regular charcoal, which, under the same conditions, burns at a much lower temperature.

It is hoped that the illustrative section which follows will show more clearly the solutions reached, and the points which may serve as the basis for further and new research.

Illustration 13

This shape has proven itself quite dependable as a casserole warmer and a brazier. The pot was thrown with a rich brown batch of S clay with a semi matte white glaze over a blue slip fired at c5. The feet are pulled. The top rim of the pot is broad enough to fit several size casseroles or a grill.

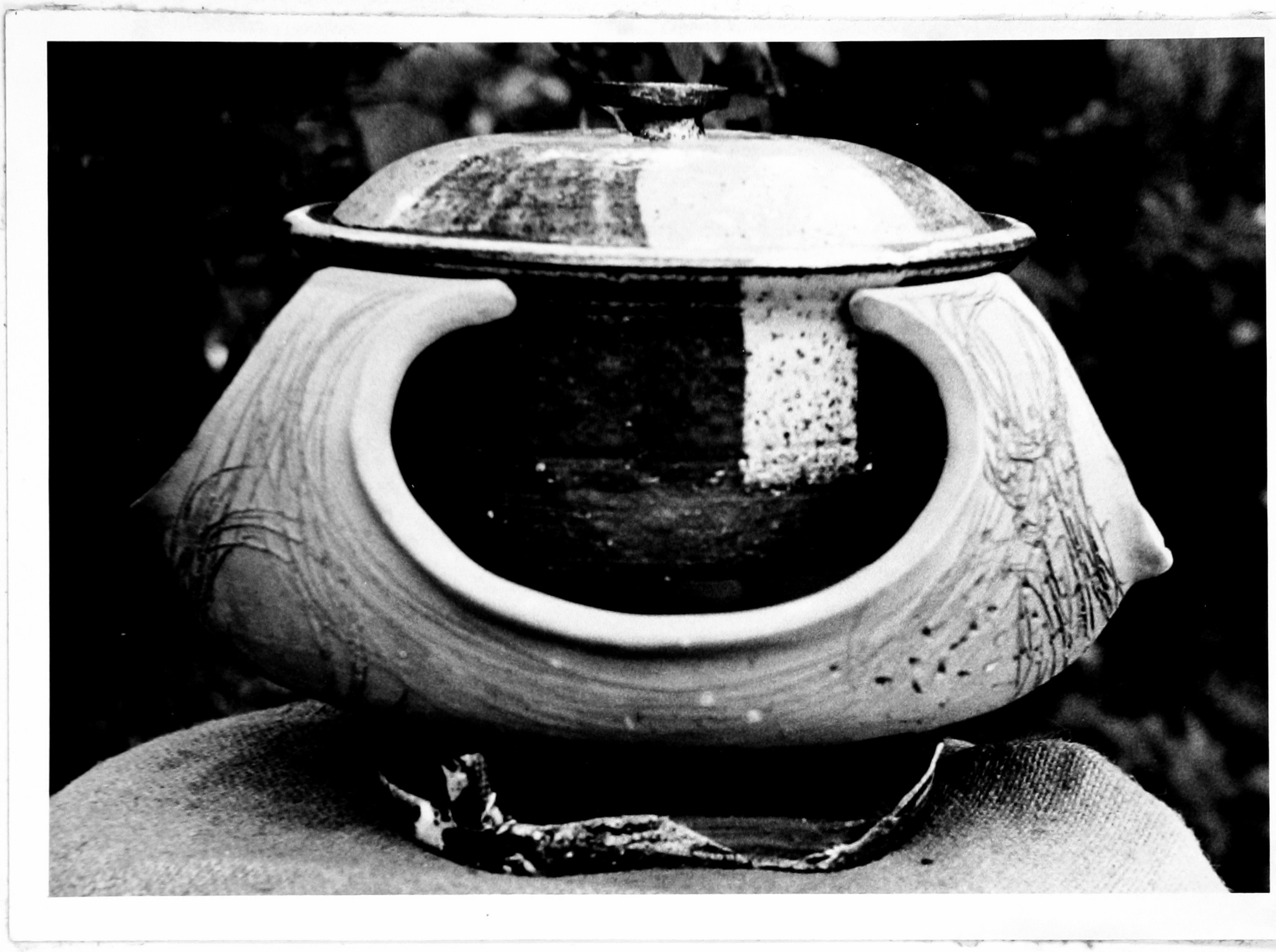
Illustration 12

This simple shape was thrown with a dark brown AC 7 clay. Decorated with a white matte glaze over a faint black slip and fired at c 5. The grill rests on three lugs below the top rim of the pot. The lugs also provide a resting place for a casserole, which because of its size allows a plentiful air supply for the coals. The inside of the pot is insulated with sand. The foot is slab constructed and glazed white over red, black and blue slips. This shape has proven itself dependable for the problem.

Illustration 14

This combination char-coal pot and casserole is missing a foot. However, it works just as well without the foot. The pot was made with only a casserole in mind. Its black clay from the SAC litho series is covered with a thick white glaze over a light blue slip. The vent holes give the impression of being pushed through. Sand was used as an insulator.

Illustration 15



Even though this pot was not fully finished and lacked the proper footing I like the idea and the shape. This combination would only be used as a soup warmer or a casserole warmer. The large openings provide ample air circulation, also give it an unpot like quality.

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